Plant biological diversity in natural secondary forests on Mao'er Mountains

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Abstract The forest plant biological diversity investigations were conducted in Laoyeling Forest Ecological Experimental Station on Mao'er Mountains in eastern Heilongjiang Province. Sample plots were six different forest communities. Field works were divided into three seasons: spring, summer and autumn in one year. The results showed that forest plant biological diversity varied with seasons as well as growth forms. Herb species diversity values were the highest in the community growth forms. Diversity indices No, H' and E_1 were selected out as the best richness, diversity and evenness indices to indicate the biological diversity in forest community.

Key words: Biological diversity, Plant species, Forest community

Introduction

Biological diversity or biodiversity is the characteristics of diverse and living entity group or class. There are many different types from gene, cell, individual, species, community to ecosystem. It's the basic characteristic of living system (Solbrig 1991). Biodiversity includes all the species and ecosystems of plants, animals and microbes, as well as the ecological process of the ecosystem (Mc Neely *et al.* 1990). This scientific term consists of quantity and frequency.

Generally, biodiversity is divided into genetic biodiversity, species biodiversity and ecosystem biodiversity to start the investigation works. Biological diversity investigations in Laoyeling Forest Ecological Experimental Station were focused on forest plant species. Field work on the plant biodiversity in the natural secondary forests and artificial forests were from early spring to late autumn, from wood, shrub to herb species. Three indices, richness, diversity and evenness, were used to contrast the difference among the communities. The varieties of biodiversity values in different seasons and growth forms indicated that forest plant biodiversity should be studied in more details.

Materials and methods

Sit forest communities were chosen out of the main secondary forests for the sample plots on Maoer Mts. They were oak forests, poplar forests, mixed-wood forests, hard broadleaf forests, artificial Korean pine forests and artificial larch forests. Broadleaf—Korean pine forests, the former climatic vegetation, was destroyed and degraded to the present natural secondary forests, where there belongs to Changbai flora. Fieldwork began from May to September in 1994, which meant the investigation included the whole growth season, from early spring until late autumn in this area. The biodiversity investigation was divided into herb species, shrub species, wood species each time in each community.

The sample area was 20 m×20 m. Detail investigation was inside 2 m×2 m small plots, 25 plots distributed randomly in the sample. Wood species area in one sample was no less than 100 m^2, 25 pieces of 1m×1m small plots for shrub and herb species. Fieldwork included the list and individual number of plant species, the diameter at breast height (DBH) and height of trees, canopy density, soil condition, altitude, direction and slope of the sample.

α biodiversity indices were adopted in the results analysis.

Richness indices were suggested by Margalef (1958).

$$R = \frac{S-1}{\ln(n)}$$

Where S was the number of species, n was the number of sample scale.

John A. L. and James F. L. recommended the number of species to contrast the richness among same scaled communities.

Diversity numbers were proposed by Hill in 1973.

$$N_A = \sum_{i=1}^{S} (P_i)^{\frac{1}{1-A}}$$

Where P_i is the individual percentage of species i in the total species individuals. While A=0, 1,2, N=S, $e^{H'}$, $\frac{1}{\lambda}$; S is the number of species, H' is Shannon index,

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λ is Simpson's index. So diversity indices developed to

$$\lambda = \sum_{i=1}^{S} P_i^2 , \quad H' = -\sum_{i=1}^{S} (P_i \ln P_i)$$

Where P_i was individual percentage of species *i*, *S* was the number of species.

Evenness indices were based on Pielou's J' (1977).

$$E_1 = \frac{H'}{\ln(S)} = \frac{\ln(N_1)}{\ln(N_0)}$$

Sheldon (1969), Heip (1974), Hill (1973) and Alatalo (1981) proposed more evenness indices, all were similar to E_1

Fieldwork data analysis in PC were supported by the software appended to Statistical Ecology by Jhon A. L. and James F. L., 1988. Richness No, diversity Shannon *H'* and evenness E_1 were computed in every community from wood species, shrub species to herb species in every growth season and the whole year.

Results and discussion

Basic habitat and environmental data were collected in the samples. Table 1 showed the general information.

Table 1. General information of the samples

Community	Crown woods	Altitude / m	Direction and slope	Canopy density	Stand section area /m²•hm⁻²
Oak forests	9 Mongolian oaks 1 Amur corktree	470	South, 15°	0.7~0.8	18.4
Poplar forest	7 poplar, 2 Manchurian walnuts, 1 Mongolian willow	460	South, 15°	0.65~0.75	5.59
Mixed-wood Forest	3 Amur lindens, 1 Manchurian linden, white birch, Mongolian oak, walnut, Elm	460	Southwest, 15°	0.65~0.75	9.41
Hard-broad leaf forests	4 Elms 2 Manchurian ashes, Amur corktree, Manchurian walnut, maple	400	Southwest 5°	0.6~0.7	6.91
Artificial Korean pine forests	6 Korean pines' 3 birches, 1 willow	410	North, 10°	0.7~-0.75	5.41
Artificial larch forests	Larches	375	Flat, 0°	0.65~0.7	10.55

Community	Dominant species, height and BD	Soil condition	Main species in regeneration	Main species in succession
Oak forests	Oak, 15.8 m & 27.62 cm Corktree, 9 m & 15 cm	Deep soil layer, abundant humus and litter	Manchurian ash, Panax, Amur honeysuckle, Spindle tree	Manchurian filbert, Maple, Elms, Lindens
Poplar forest	Poplar, 13.5 m & 15 cm Walnut, 11 m & 20 cm Willow, 11 m & 20 cm	Deep soil layer, rich humus and little litter	Manchurian ash, Mongolian oak White birch	Elms, Amur lilac, Panax
Mixed-wood Forest	Linden, 13 m & 14.8 cm Birch, 16 m & 19.5 cm Elm, 15 m & 21 cm	Very deep soil layer, Rich humus and litter	Maple Mongolian oak	Manchurian filbert, Lilac, Plums
Hard-broad leaf forests	Elm, 15 m & 16 cm Ash, 11.4 m & 14 cm Corktree, 19 m & 14 cm Walnut, 26 m & 15 cm	Deep soil layer, rich humus and litter	Manchurian ash	Lilacs
Artificial Korean pine forests	Korean pine, 9 m & 11.7m Birch, 9 m & 11 cm Ash, 12 m & 16 cm	Deeper soil layer, Much humus and litter	Maple, Mongolian oak, Manchurian filbert, Aamur honeysuckle	Japanese elm
Artificial larch forests	Larch, 17 m & 27 cm	Very deep soil, reach humus and litter	Maple, Spindle tree	Manchurian ash, elm

The climatic Korean pine plantation on Mao'er Mts was severely exploited during the railway construction by Russian government in 1900s. The forests degraded to current natural secondary forests amid some artificial Korean pine and larch forests. They differed in ages and habitats, so did the plant biodiversity.

Poplar community had 13 wood species with the highest richness and diversity (See Fig. 1). The wood species were *Acer* sp., *Acer mono, Tilia amurensis, Tilia manchurica, Fraxinus manchurica, Populus dividiana, Ulmus dividiana, Ulmus laciniata, Ulmus macrocarpa, Salix matsudana, Juglans manchurica, Salix mongolia, Ulmus pumila*. Mixed wood and artifi-

cial larch communities were second to Poplar community with 10 wood species respectively. Most wood species in mixed-wood community were *Tilia amurensis, Phellodendron amurensis, Juglans manchurica, Acer mono, Ulmus pumila, Betula costata.* Only 6 wood species were found in hard broadleaf community with the lowest richness, diversity and evenness. Artificial Korean pine community had the highest evenness.

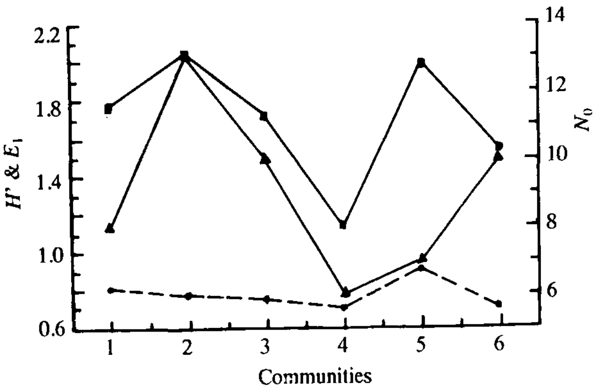

Fig. 1. Density indices of wood species in the year

—▲— N_0, —■— H' , ----●---- E_1

Poplar community also had 17 shrub species with the highest richness and diversity. The main species were *Corlus manchurica, Acer mandchurica, Syriga armurensis, Spiraea ussuriensis, Lonicera maackii, Ribes mandchuricum, Euonymus pauciflorus, Vitis amurensis, Actinidia kolomikta, Panax* sp., *Deutzia glabrata.* Only 9 shrub species presented in Hard-broad leaf community with the lowest richness, diversity and evenness. Mixed-wood community had the highest evenness in shrub species due to the evenly distribution of species individuals. See Fig 2.

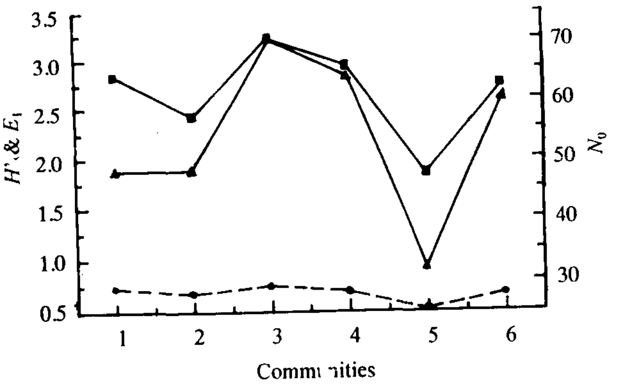

Fig. 2. Density indices of shrub species in the year

—▲— N_0, —■— H' , ----●---- E_1

70 herb species grew in mixed-wood community contributing to the highest richness, diversity and evenness. The main species were *Equisetum hyemale, Caradamine leucantha, Galium dahuricum, Brachybotrys paridiformis, Adoxa moschatellina, Adomis amurensis, Saussurea pulchella, Viola rossii, Kraschenінni kouia davidi, Gagea corena, Perulara fuscescens, Anemone raddeana, anemone amurensis, Polygonatum involucratum, Hylomecon vernais, Carex campylorhina, Diarrhena manshurica, kraschenіnnikouia maximnuiczii, Geum aleppicum, Urtica angustifolia, Lamium album, Vicia amoena.* Only 32 herb species were under artificial Korean pine forests, had the lowest richness, diversity and evenness. See Fig. 3.

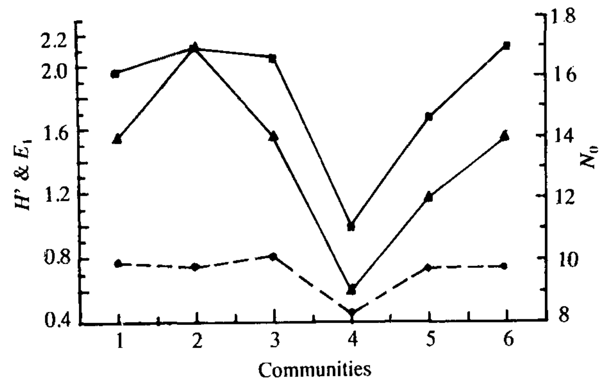

Fig. 3. Density indices of herb species in the year

—▲— N_0, —■— H' , ----●---- E_1

In the whole year among the 6 communities, mixed-wood forests had 94 plant species with the highest richness, diversity and evenness, while artificial Korean pine forests only had 51 species, got the lowest richness, diversity and evenness. See Fig. 4.

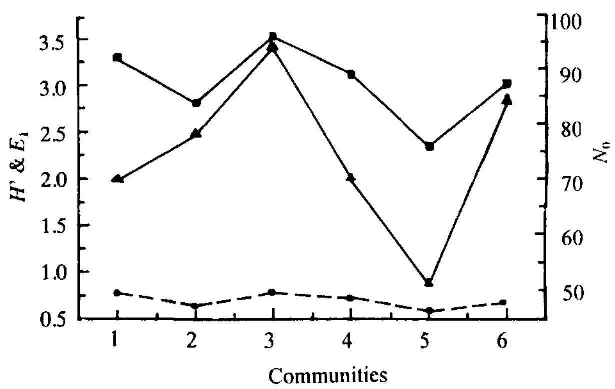

Fig. 4. Density indices of the communities in the year

—▲— N_0, —■— H' , ----●---- E_1

Cold weather and ecological habitat limited the growth of herb species in artificial Korean pine forests. Normally, herb species played a key role in richness,

diversity and evenness of the community, while mixed-wood community was well ventilated with good humidity and heat as well as its soil condition. Most wood species shoot late in spring, which offer an opportunity for many early-spring plants to grow under the bald trees with enough sunshine and water from melting snow. Moss species such as *Anomodon minor, Myuroclada maximouiczii* were abundant around the roots of trees.

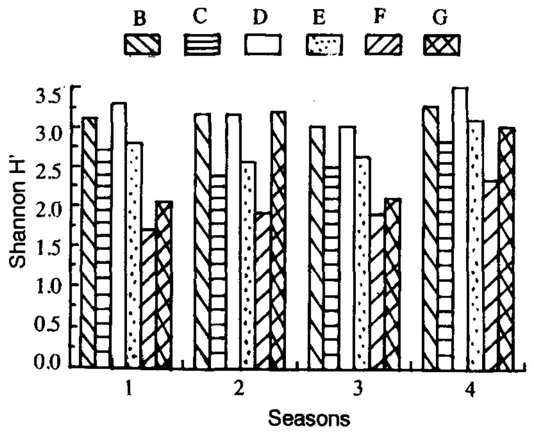

Fig. 5. Density index Shannon *H'* in different communities in the year

B, C, D, E, F, G Respectively represented oak, poplar, mixed wood, hard broadleaf, artificial Korean pine and larch communities. Number 1, 2, 3, 4 on X-axis respectively stands for spring, summer, autumn, and the year.

Diversity index Shannon *H'* changed from spring, summer to autumn in every communities. Oak forests, Korean pine forests, larch forests had the highest diversity in summer. Comparably, the highest diversity occurred in spring in popular forests, mixed-wood forests and hard broadleaf forests, because of the contribution from short-lived early-spring herb species. See Fig. 6.

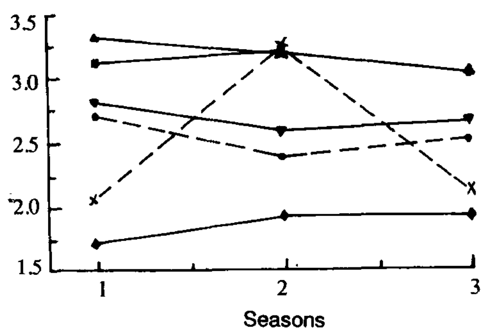

Fig. 6. Density index Shannon *H'* in different communities in the year

—■—B, ---●---C, —▲—D, —▼—E, —◆—F, ---×--- G

In poplar forests, there was a serious problem named group-dead of poplar trees with unknown reasons, which resulted to the abundant growth of several well-climate shrub species and limited the development of herb species. In mixed-wood forests, diversity decreased with the disappearance of early-spring species. The same happened to hard-broad leaf forests with big crowns and high canopy density limiting the growth of some herb species. It's easier to understand that more herb species appeared in summer contributing to the highest diversity in oak, Korean pine and larch communities.

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